

PATENT SPECIFICATION (11)

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(72) Inventors TOSHIRO YAMADA and KOUKI KANI

(54) PLASTIC DEFORMATION METHOD FOR SHAPING MATERIAL BY USING IMPACT PRESSURE OF LIQUID

(71) We, KYOTO UNIVERSITY, an organisation established by the Japanese Government, of Yoshida Honmachi, Sakyo-ku, Kyoto, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

There have been various methods for producing a high liquid pressure and various methods for shaping material by means of the liquid pressure. A typical example of the conventional methods utilizes a heavy weight piston of metal and a corresponding cylinder, in which the piston is moved against a liquid medium in the closed cylinder at a relatively low speed. In this method since the relative speed of the piston to the cylinder and hence the liquid medium may be 20—30 m/sec. at most, the pressure in the liquid is produced by a static direct compression of the liquid medium. This method is satisfactory for some purposes. However, due to the fact that it requires a metal piston which is heavy and large in size and a cylinder of corresponding size for receiving the piston, the apparatus for performing this method is necessarily large in size and the piston and the cylinder must be machined exactly to maintain the sealing structure, causing the method to be expensive and the maintenance of the apparatus to be difficult.

In accordance with the invention a method of plastically deforming a metal plate comprises the steps of disposing the metal plate, which is in the form of a container having an open upper end, in a facing relationship to a surface of a solid member, providing a liquid medium within the container, and striking the surface of the liquid medium with a pellet travelling at a velocity in a range from several hundreds to several thousands meters per second at the moment of impact to produce a high shock pressure in the liquid medium and thereby cause the metal plate

to move against the surface of the solid member.

According to this method, it is unnecessary to use a heavy piston and cylinder and to maintain the sealing relation therebetween, so that the disadvantages inherent to the conventional method can be overcome. This is because the present method utilizes an open container and a high speed bullet which may be small in size and light-weight. The mechanism of production of high liquid pressure according to the present method is thus by an acceleration of liquid particles to high speeds by the high speed bullet rather than the compression of the liquid as in the conventional piston and cylinder method.

The present invention also provides an article which has been produced by utilizing the high pressure shock wave generated according to the present method. The necessary apparatus is very simple in construction and economical in comparison with apparatuses constructed for use with the conventional method.

Two examples of apparatus for carrying out the method according to the invention are illustrated in the accompanying drawings, in which:—

Figure 1 is a schematic cross sectional view of one apparatus which is suitable to perform a plastic deformation of material; and,

Figure 2 is a schematic cross sectional view of another apparatus which is suitable to provide a lining.

In Figure 1, the upper part illustrates a device supported suitably for propelling a small and lightweight piece 2 such as a bullet made of metal or plastics material, downwardly. The device comprises a firing chamber 1 for receiving a propellant and firing it to produce a high pressure gas and a barrel portion 3 having a bore along which the small bullet 2 is accelerated by the high pressure gas.

The lower part of Fig. 1 illustrates a

generally cylindrical die member 5 having a centre hole the diameter of the middle portion of which is, in this case, increased. Within the centre hole, a container 4 is disposed. The container 4 has an open upper end facing to the muzzle of the barrel 3 and is filled with a suitable liquid medium 6. The die 5 and the container 4 are suitably supported with respect to each other and to the barrel 3 as shown. A workpiece to be plastic-deformed constitutes a portion of the side wall of the container.

In operation, the bullet 2 is loaded into the barrel 3 as shown and a suitable explosive is charged in the chamber 1. The explosive is fired suitably to produce a high gas pressure in the chamber 1, which forces the bullet 2 to move.

The bullet 2 is accelerated by the gas pressure while passing through the bore of the barrel 3 and expelled from the muzzle at an initial velocity, at which it strikes the liquid, in a range from several hundreds m/sec to several thousands m/sec. The bullet 2 strikes a surface of the liquid 6 in the container 4 and accelerates liquid particles thereof. Upon the acceleration of the liquid particles, a very high shock liquid pressure is produced in the container 4. Therefore, the container wall is forced outwardly against the inner wall of the die 5 at a high speed, resulting in a plastic deformation of the container wall, the final shape being defined by the shape of the inner wall of the die 5.

Fig. 2 shows another embodiment which is similar to the first embodiment in Fig. 1 except that a cylindrical metal container 7 filled with a liquid is disposed in a metal cylinder 8 which is to be lined with the wall portion of the container 7. In this embodiment, the bullet 2 is accelerated and directed into the liquid in the same manner as in the first embodiment to produce a high shock pressure in the liquid. Due to the high pressure, the wall of the metal container 7 is accelerated against the inner wall of the metal cylinder 8 and collides therewith. Upon the collision of the wall of the metal container 7 to the inner surface of the cylinder 8, the wall adheres to the inner surface as a lining. The interface between the inner surface and the lining exhibits a complete metallurgical bonding as is obtainable when the lining is provided by explosive formation.

As mentioned hereinbefore, the present

method can be performed with a very simple apparatus and without requiring complicated hardlings or processes. Further, although the bullet has been described as being expelled from the barrel by explosive pressure, it should be noted that any pressure source other than explosive can be used to accelerate the bullet. For example, a compressed gas source can be used if it is sufficient to accelerate the bullet to a muzzle velocity in a range from several hundreds m/sec to several thousands m/sec.

WHAT WE CLAIM IS:—

1. A method of plastically deforming a metal plate comprising the steps of disposing the metal plate which is in the form of a container having an open upper end, in a facing relationship to a surface of a solid member, providing a liquid medium within the container, and striking the surface of the liquid medium with a pellet travelling at a velocity in a range from several hundreds to several thousands meters per second at the moment of impact, to produce a high shock pressure in the liquid medium and thereby cause the metal to move against the surface of the solid member.
2. A method as claimed in claim 1, wherein the pellet is directed at right angles to the surface of the liquid medium.
3. A method as claimed in claim 1 or claim 2, wherein the solid member is disposed around the container and acts as a die.
4. A method as claimed in claim 1 or claim 2, wherein the solid member takes the form of a cylinder and is disposed coaxially around the container.
5. A method as claimed in any one of the preceding claims, wherein the pellet is accelerated by an explosive pressure.
6. A method as claimed in any one of claims 1 to 4, wherein the pellet is accelerated by a compressed gas pressure.
7. A method according to claim 1, substantially as described with reference to Figure 1 or Figure 2 of the accompanying drawings.
8. An article which has been produced by a method according to any one of the preceding claims.

For the Applicants,
GILL, JENNINGS & EVERY,
Chartered Patent Agents.
53/64 Chancery Lane,
London, WC2A 1HN.

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FIG. 1

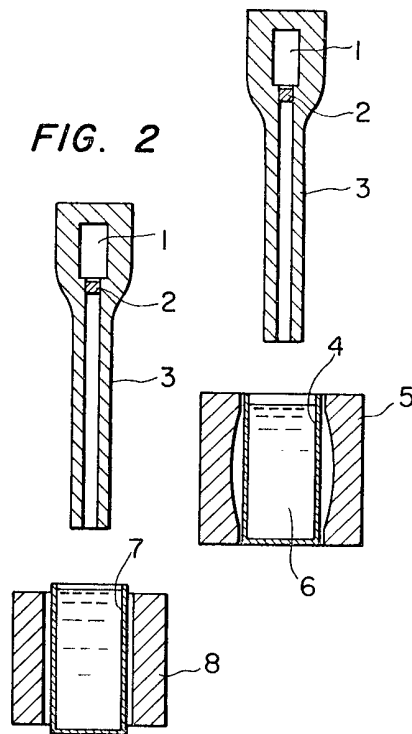


FIG. 2